DEPARTMENT OF THE ARMY
MILITARY TRAFFIC MANAGEMENT COMMAND
TRANSPORTATION ENGINEERING AGENCY
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REPLY TO
ATTENTION OF:

MTTE-DPE (70-44a) 23 April 2003

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Transportability Assessment of the Future Combat Systems (FCS) for Milestone B (DP 00-18)

1. References:

a. DoD Directive 4510.11, DoD Transportation Engineering.

b. AR 70-44/OPNAVINST 4600.22B/AFR 80-18/MCO 4610.14C/DLAR 4500.25, DOD Engineering for Transportability.

c. AR 70-47, *Engineering for Transportability*.

d. Operational Requirements Document (ORD) for the Future Combat Systems, 14 Apr 03.

e. Historic Weight Growth of U.S. Army Combat Vehicle Systems, MTMCTEA, 27 Aug 02.

f. C-130E/H/J/J-30 Transportability of Army Vehicles, MTMCTEA, 11 Sep 02.

g. Memorandum of Agreement Between the U.S. Air Force and the U.S. Army for Air-Transport of the Stryker, Departments of the Air Force and Army, 4 Feb 03.

2. Reference 1a establishes that the Secretary of the Army shall promote a coordinated transportability engineering program between the Department of Defense (DoD) Components through providing transportability engineering advice and assistance and ensuring the publication of a multi-service regulation to implement the transportability engineering program. Reference 1b designates the transportability agencies, promulgates policy, assigns responsibilities, and outlines procedures for conducting the DOD Engineering for Transportability Program within the services, designating the Commander, Military Traffic Management Command (MTMC) as the Army Transportability Agent. As the Army Transportability Agent, MTMC is responsible for providing transportability assessments during the concept evaluation and materiel acquisition process, culminating with Transportability Approval before procurement contract award. Reference 1c establishes the MTMC Transportation Engineering Agency (MTMCTEA) as the single point of contact for Army agencies in securing transportability engineering analyses and assistance, detailing the need for a transportability assessment before each Milestone and a deployment assessment during concept

development. Therefore, in accordance with the requirements of references 1a through 1c, MTMCTEA has performed the following assessment of the transportability and deployability of the Future Combat Systems.

3. The FCS consists of both manned and unmanned vehicles. The U.S. Army Materiel Systems Analysis Activity (AMSAA) has written and maintains the *Army Future Combat Systems Unit of Action Systems Book*. The *Systems Book*, Version 1.6, dated 24 February 2003, was used as a source of vehicle information for this assessment. Table 1 shows a list of manned and unmanned vehicles, their abbreviations, and their essential combat configuration (ECC) and their full combat configuration (FCC) weights.

Table 1: FCS Manned and Unmanned Vehicle List*

MANNED Vehicles	**ECC**	**FCC**
Mounted Combat System (MCS)	18 tons	22 tons
Infantry Carrier Vehicle (ICV)	16 tons	22 tons
Non-Line-of-Sight Mortar (NLOS M)	16 tons	22 tons
Non-Line-of-Sight Cannon (NLOS C)	18 tons	22 tons
Command and Control Vehicle (C2V)	16 tons	22 tons
Reconnaissance and Surveillance Vehicle (R&SV)	16 tons	22 tons
Medical Vehicle (MV)	16 tons	22 tons
FCS Recovery & Maintenance Vehicle (FRMV)	16 tons	22 tons
UNMANNED Vehicles	**ECC**	**FCC**
Armed Robotic Vehicle – Assault Variant (ARV-A)	5 tons	5 tons
Armed Robotic Vehicle – Assault Variant Light (ARV-AL)	2.5 tons	2.5 tons
Non-Line-of-Sight Launch System (NLOS LS)	1.4 tons	1.4 tons
Armed Robotic Vehicle – Recon., Surv., & Target Aq. (ARV-RSTA)	5 tons	5 tons
Unmanned Aerial Vehicle – Class I (UAV-CL I)	10 lbs	10 lbs
Unmanned Aerial Vehicle – Class II (UAV-CL II)	160 lbs	160 lbs
Unmanned Aerial Vehicle – Class III (UAV-CL III)	300 lbs	300 lbs
Unmanned Aerial Vehicle – Class IVa (UAV-CL IVa)	1000 lbs	1000 lbs
Unmanned Aerial Vehicle – Class IVb (UAV-CL IVb)	2 tons	2 tons
Small Unmanned Ground Vehicles (SUGV)	30 lbs	30 lbs
Multifunction Utility/Logistics Equipment Vehicle (MULE)	TBD	TBD

**Source: AMSAA Systems Book Version 1.6, 24 February 2003*

ECC as defined in reference 1d is a full basic load and a full turret of fighting load of ammunition, a ¾ tank of fuel, with its full crew and passengers with their personal equipment. FCC as defined in reference 1d is ECC, plus a full fuel tank and basic loads needed for 72 hours of high tempo operations and all add-on armor kits applied.

4. Reference 1d defines the requirements for the FCS. A key performance parameter (KPP# 4) defined in the 14 Apr 03 ORD states that:

> *The FCS FoS [Family of Systems] must be transportable worldwide by air, sea, highway, and rail modes to support inter-theater strategic deployment and intra-theater operational maneuver.*
>
> ***Rationale:*** *FCS FoS transportability provides inter-theater options for strategic deployment and intra-theater options for operational maneuver in order to execute a range of missions within a campaign. This capability provides flexibility for entry operations (permissive and non-permissive) to counter threat anti-access strategies by using multiple austere entry points to bring in combat configured units. Within the context of theater campaigns, operational maneuver by multiple modes facilitates the execution of Joint operations, [multi-modal transportable to a range greater than 250NM (Threshold) to a range greater than 500NM (Objective)].*

The "multi-modal transportable to a range greater than 250 NM (threshold) and 500 NM (objective) within the context of theater campaigns" is a new objective added to the 14 Apr 03 ORD. Also in the 14 Apr 03 ORD is the following statement:

> *The UA Brigade is able to conduct the following core mission tasks: Execute up to a battalion-sized tactical air assault, using external lift aircraft* ***(ORD, 14 Apr 03, paragraph 1.5.1.4)***

This statement appears to set forth a requirement for external air transport (EAT) for the FCS manned vehicles. This would mean that the maximum weight for an FCS vehicle would be 16,644 pounds (8.3 tons) to be able to be transported by a CH-47 helicopter. Further in the 14 Apr 03 ORD, the following two paragraphs discuss transportability and deployability of the manned and unmanned vehicles:

> *The FCS FoS must be Essential Combat Configuration (ECC) transportable worldwide, with disassembly, by air, sea, rail and highway modes. The FCS FoS must be ECC transportable on C130, C-17, and C-5 profile aircraft; maritime pre-positioned ships, break bulk (general cargo), Roll-on/Roll-off, barge carrying, container ships, and on all vessels of the Army, Navy, and Marine Corps strategic/tactical sea-lift watercraft fleet; and rail/highway transport (Threshold); tactical watercraft fleet to include shallow draft high-speed sealift and landing craft. (Objective)* ***(ORD, 14 Apr 03, paragraph 4.1.1.2.1.3)***
>
> *The FCS FoS must be ECC transportable by C-17 and C-130 profile aircraft (ECC no greater than 38,000 lbs, and size suitable for transport as determined by USAF*

> *Aeronautical Systems Center Air Transportability Test Loading Agency (ASC/ENFC (ATTLA)) (Threshold). The objective capability is 1,000 NM using new, advanced intra-theater aircraft (Objective). Once off loaded, the FCS FoS must be capable of rapid transition to Full Combat configuration (FCC) (Objective).* ***(ORD, 14 Apr 03, paragraph 4.1.1.2.1.4)***

Additionally, the 14 Apr 03 ORD states the following for FCS unmanned systems:

> *All FCS UMS must be capable of being carried during AASLT/air mobile by UH-60 and/or CH-47 helicopters in a high altitude, (4,000 foot pressure altitude), hot temperature (95 degrees F.) scenario for a radius of at least 75-150 km. The vehicle operators/crew will travel inside the helicopter and will be considered as part of the helicopter cargo. (Objective)* ***(ORD, 14 Apr 03, Annex E, paragraph 2.0.2.1.1)***
>
> *UAV (CL IV) must be capable of being sling-loaded by a CH-47. (Objective)* ***(ORD, 14 Apr 03, Appendix A to Section 1 of Annex E, paragraph 2.0.2.1.1)***
>
> *FCS ARV variants must be capable of being airdropped from C-130 aircraft and arrive mission capable on a drop zone in an operational configuration, ready for immediate employment, ARV-A (Threshold), ARV-RSTA and ARV-AL. (Objective)* ***(ORD, 14 Apr 03, Appendix A to Section 2 of Annex E, paragraph 2.0.2.1.4)***

5. MTMCTEA uses the follow definitions when it comes to transportability and deployability:

Transportability – the inherent capability of military materiel (a piece of equipment) to be moved efficiently by existing or planned transportation assets.

Deployability – the capability of the force (people and equipment) to be moved anywhere in the world to support a given military operation.

6. Transportability Assessment. The AMSAA Systems Book (Version 1.6) does not provide any dimensional data for the manned or the unmanned vehicles listed in table 1. However, based on the ORD requirements, it is MTMCTEA's conclusion that the controlling factor is the C-130 transport requirement. Based on this, the practical maximum dimensions for the manned vehicles that would enable C-130 transport are as follows:

- Length: No longer than 400 inches

- Width: With air crew and passengers, comply with the passenger safety aisle requirement of no wider than 99 inches (see figure 1).
  OR
  Air crew only (no passengers, see figure 2, loadmaster safety aisles) – no wider than 107 inches to a height of 36 inches above the floor, no wider than 99 inches above a height of 36 inches, and no wider than 100 inches at the floor to a height of 5.5 inches;
  OR
  No wider than 107 inches to a height of 60 inches above the floor, no wider than 83 inches above a height of 60 inches, and no wider than 100 inches at the floor to a height of 5.5 inches;

- Height: No taller than 102 inches when in ECC (the Air Force has certified vehicles up to 105.5 inches under special circumstances)

The FCS unmanned vehicles, specifically the unmanned ground vehicles, may require some type of "solid wire connection" available to drive them up and down the ramps of aircraft. In forward operating airfields, where the aircraft does not shut down the engines for offloading, radio controlled operation of the unmanned vehicles may not be practical due to possible interference with the aircraft avionics. This "solid wire connection" may also be needed for rail and ship loading of the unmanned systems. If this is the case, typical loading times might have to be adjusted to take into consideration an operator walking along side the unmanned vehicle to load it on the transportation vehicle (ship, railcar, or aircraft). Radio controlled operations might be a problem during Logistics Over The Shore (LOTS) operations due to radio interference from ships electronics equipment as well. We will coordinate with the Association of American Railroads (AAR) and the Military Sealift Command (MSC) on these remote controlled unmanned vehicle issues.

Table 2 shows a weight comparison between the 14 Apr 03 ORD weight requirements and contractor estimates as briefed at the Alternative Systems Review (ASR), 28 Mar 03. These weights are a "snapshot" of contractor estimates on that date and are in a state of flux as designs are finalized. Paragraph 4.1.1.2.1.4 of the 14 Apr 03 ORD clearly establishes a maximum ECC weight of 19 tons (38,000 pounds).

Table 2: FCS Manned Vehicle Weight Comparison

MANNED Vehicles	ORD Maximum 14 Apr 03	Contractor Estimates*	
	ECC	**ECC**	**FCC**
Mounted Combat System (MCS)	19 tons	24.2 tons	25.7 tons
Infantry Carrier Vehicle (ICV)	19 tons	22.5 tons	23.3 tons
Non-Line-of-Sight Mortar (NLOS M)	19 tons	24.3 tons	27.1 tons
Non-Line-of-Sight Cannon (NLOS C)	19 tons	24.8 tons	28.4 tons
Command and Control Vehicle (C2V)	19 tons	22.9 tons	23.7 tons
Reconnaissance and Surveillance Vehicle (R&SV)	19 tons	23.2 tons	24.0 tons
Medical Vehicle (MV)	19 tons	22.9 tons	23.6 tons
FCS Recovery & Maintenance Vehicle (FRMV)	19 tons		

* Source: Alternative Systems Review (ASR), 28 Mar 03

The following paragraphs are from reference 1d.

> *FCS Manned Systems must be ready to fight as coherent CA teams with mission support enablers; with all crews, squads, and initial sustainment having deployed on the same sorties as their respective FCS Manned Systems in FCC (excluding add-on armor) within 30 minutes (Threshold), 15 minutes (Objective) upon arrival. FCS Manned Systems must be capable of employing their primary and secondary weapons and protective systems upon initiation of main power to the system. (Threshold)* ***(ORD, 14 Apr 03, Annex D, paragraph 2.0.1.1.1)***
>
> *FCS Manned Systems must be capable of incorporating an add-on armor protection package. The package must be attached safely in 30 minutes (Threshold)/15 minutes (Objective) and detached safely in 30 minutes by the crew without any specialized Material Handling Equipment (MHE). (Objective) ** Threshold measure may be adjusted based on analytical data prior to ORD validation.* ***(ORD, 14 Apr 03, Annex D, paragraph 2.0.1.1.2)***

In the first paragraph, it seems to infer that all removed equipment and 72 hour sustainment, less the add-on armor, have to fly on the same aircraft as the vehicle the equipment is removed from. This would increase the total payload on that aircraft higher than the 19 ton ECC vehicle requirement. Once in theater, the maximum amount of time to reconfigure from ECC to FCC is 60 minutes (30 minutes for the add-on armor and 30 minutes for everything else).

For the following summary of transport modes, guidance on dimensional restrictions is provided.

a. Fixed-Wing Air. The Air Force's Air Transportability Test Loading Agency (ATTLA) is responsible for providing air transport certifications for vehicles carried aboard Air Force aircraft. MTMCTEA uses ATTLA's memorandum as part of the final transportability approval, which will be required prior to Milestone C. MTMCTEA requested clarification on the requirements to obtain air transport certification by ATTLA and, on 14 Mar 03, they provided the following statement:

> *Design of the FCS vehicles must meet all of the requirements of MIL-HDBK-1791 [as referenced by MIL-STD-1366], including the loadmaster and passenger safety aisles required by MIL-HDBK-1791 and Air Force Instruction 11-2C-130 Volume 3 Addenda A. Vehicles must be capable of certification without waivers of any Air Force loading or flight requirements. FCS vehicles will not be considered to be capable of C-130 transport until the Air Force's ATTLA has certified the vehicle for C-130 transport. The Stryker was accepted because it supposedly was an "off the shelf" existing design. The USAF expects the new FCS to at least start out by being designed to fit inside the C-130 without exceeding established limits for weight or size and to provide acceptable space for access/escape.*

The dimensions for the passenger and loadmaster safety aisle as defined by MIL-HDBK-1791 can be seen in figures 1 – 2.

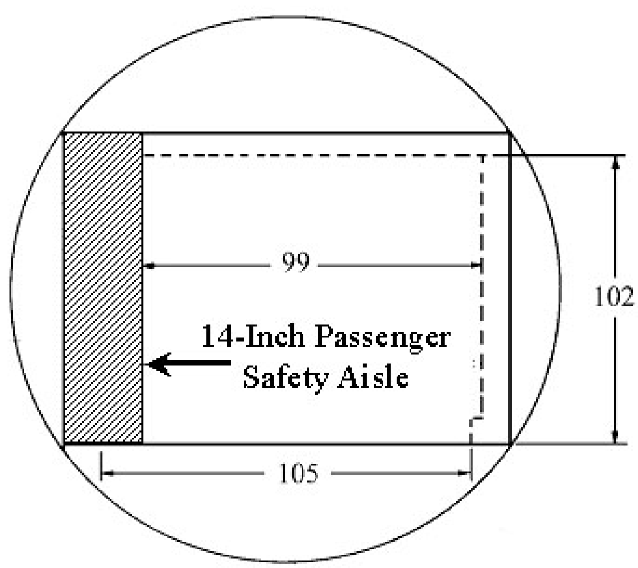

Figure 1: Passenger Safety Aisle

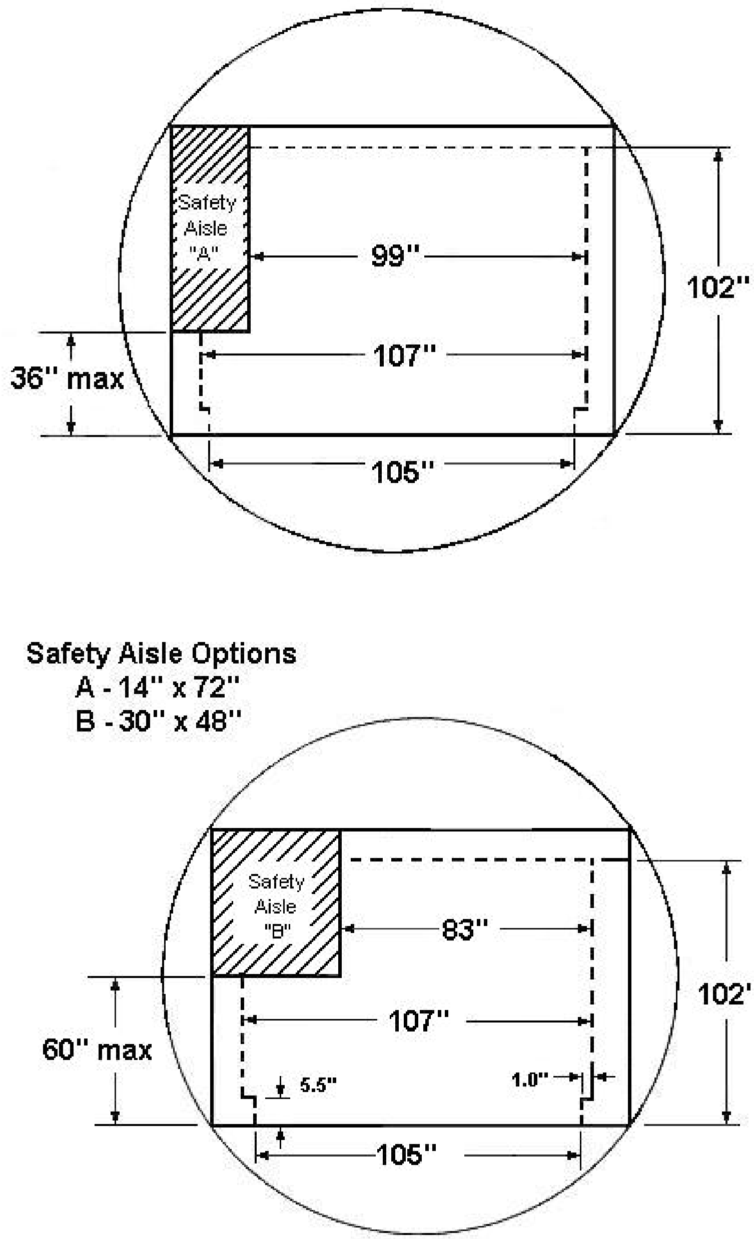

Figure 2: Loadmaster Safety Aisles

Fixed-wing air transport of the FCS vehicles, using both the 14 Apr 03 ORD requirements (table 2) and the Contractor Estimated weights (table 2), will be as follows. The dimensions of all vehicles are assumed not to exceed the maximum C-130 design limits shown on page 5 of this analysis.

(1) 14 Apr 03 ORD Required Weight - All manned FCS vehicles, at their ECC weight of 19 tons, will be capable of C-130, C-17, and C-5 internal air transport. At their AMSAA Systems Book Version 1.6 FCC weights of 22 tons, all manned FCS vehicles will be capable of C-17 and C-5 internal air transport. All unmanned FCS vehicles, at both their ECC and FCC weights of 5 tons or less, will be capable of C-130, C-17, and C-5 internal air transport, and, depending on final dimensions, also in Civil Reserve Air Fleet (CRAF) aircraft.

(2) Contractor Weight Estimates - The manned FCS vehicles, at their ECC weights starting at 22.5 tons, will not be capable of C-130 internal air transport. However, they will be capable of C-17 and C-5 internal air transport. At their FCC weights of 23.3 tons and higher, all manned FCS vehicles will be capable of C-17 and C-5 internal air transport. The contractor has instituted a weight reduction program with a goal towards reducing the FCS manned vehicle ECC weights to a maximum of 19 tons. At 19 tons, all manned FCS vehicles will be capable of C-130, C-17, and C-5 internal air transport.

The weights of the proposed FCS vehicles are in a state of flux. Reference 1e details the historic weight growth of Army combat vehicles. While not totally inevitable, weight growth of the FCS vehicles over their life cycles is likely. Therefore, the following tables are presented to show the effects of weight growth on the capability of a vehicle to be moved by a C-130 aircraft. It is not MTMCTEA's role to establish the desired weights of the FCS vehicles, but to advise the PM and the materiel and combat developers on the transportability tradeoffs that occur as the weights of those vehicles increase. The tradeoffs include the ability to use a particular type of transportation asset, such as a C-130, and how far a payload (vehicle, personnel, and equipment) might be transported aboard those assets (range). Tables 3 – 5, using information provided by the Air Mobility Command (AMC), show the effect of such weight growth (12.5% and 25%) on the range of armored C-130H, C-130J, and C-130J-30 (CC-130J) aircraft. These tables are at ideal operating conditions, sea level (0-feet) and standard day temperature of 59 degrees F. As a general rule, as field elevation and temperature increases, aircraft performance (payload capability) decreases. Designing the FCS vehicles at an upper weight limit for C-130 transport (as shown in tables 3 – 5) leaves no room for airfields not at sea level or 59 degrees F. In other words, the vehicles may not be C-130 transportable in high/hot locations such as Afghanistan. But even at the required weight of 38,000 pounds (capable of 860 NM in a C-130), a weight growth of 12.5% (42,750 pounds) would result in a range of 0 NM in all but the C-130J-30 (capable of 105 NM).

Table 3: Effect of System Weight Growth on Armored C-130H Range

Original System Weight (pounds) considered as payload	Original System C-130H Range (nautical miles)*	12.5% System Weight Growth (pounds)	12.5% System Weight Growth C-130H Range (nautical miles)*	25% System Weight Growth (pounds)	25% System Weight Growth C-130H Range (nautical miles)*
32,000	1,320	36,000	1,040	40,000	500
34,000	1,200	38,250	800	42,500	0
36,000	1,040	40,500	390	45,000	0
38,000	**860**	**42,750**	**0**	**47,500**	**0**
40,000	500	45,000	0	50,000	0
42,000	60	47,250	0	52,500	0

*Assumes armored aircraft, ideal operating conditions, normal landing, and fuel available for aircraft at destination airfield.

Table 4: Effect of System Weight Growth on Armored C-130J Range

Original System Weight (pounds) considered as payload	Original System C-130J Range (nautical miles)*	12.5% System Weight Growth (pounds)	12.5% System Weight Growth C-130J Range (nautical miles)*	25% System Weight Growth (pounds)	25% System Weight Growth C-130J Range (nautical miles)*
32,000	1,975	36,000	1,350	40,000	550
34,000	1,850	38,250	940	42,500	0
36,000	1,350	40,500	425	45,000	0
38,000	**1,000**	**42,750**	**0**	**47,500**	**0**
40,000	550	45,000	0	50,000	0
42,000	70	47,250	0	52,500	0

*Assumes armored aircraft, ideal operating conditions, normal landing, and fuel available for aircraft at destination airfield.

Table 5: Effect of System Weight Growth on Armored C-130J-30 (CC-130J) Range

Original System Weight (pounds) considered as payload	Original System C-130J-30 Range (nautical miles)*	12.5% System Weight Growth (pounds)	12.5% System Weight Growth C-130J-30 Range (nautical miles)*	25% System Weight Growth (pounds)	25% System Weight Growth C-130J-30 Range (nautical miles)*
32,000	2,331	36,000	1,700	40,000	750
34,000	2,199	38,250	1,170	42,500	120
36,000	1,700	40,500	600	45,000	0
38,000	**1,225**	**42,750**	**105**	**47,500**	**0**
40,000	750	45,000	0	50,000	0
42,000	150	47,250	0	52,500	0

*Assumes armored aircraft, ideal operating conditions, normal landing, and fuel available for aircraft at destination airfield.

Note that an armored C-130 was used in Tables 3 – 5 under the direction of the U.S. Transportation Command (USTRANSCOM). The armor protects the crew and key systems and weighs approximately 1,600 pounds, which counts as aircraft payload. Table 6 (from reference 1f) shows the current and projected numbers of C-130 aircraft in inventory through 2020. The numbers of anticipated aircraft in inventory is a volatile number and is thus subject to change. For more information on the C-130, see reference 1f.

Table 6: Current and Projected C-130 Inventory

Model	2002	2008	2016	2020
C-130E*	209	112	33	33
C-130H*	286	282	282	282
C-130J	12	12	12	12
C-130J-30 (CC-130J)	5	51	138	138
Total:	**512**	**457**	**465**	**465**

Source: Air Mobility Command (XPP)
* Some E and H model aircraft will be modernized and re-designated under the Avionics Modernization Program (C-130 AMP) over the next 15 years.

Another design consideration should be axle-loads and track contact pressure on the C-130. For wheeled vehicles, the axle-loads are limited to 13,000 pounds (6,500 pounds on each wheel). With hybrid electric vehicles being considered for the FCS manned vehicles, axle-loads and wheel-loads need to be closely monitored due to the weight of batteries. For tracked vehicles, the treadway-limit is 6,000 pounds per linear foot (3,000 pounds per side). Loads are calculated based on linear length of track in contact with the floor. To reduce axle-loads/treadway-limits, shoring may be used. However, the weight of shoring counts as payload on the flight and the height of shoring may necessitate a reduction in the height of the vehicle. A pneumatic tire above a band track would be treated as though it were the tire (at up to 100 psi inflation pressure) supported by the track contacts. This is similar to large tires with aggressive tread designs (big mud grips). These are typically analyzed as generating somewhat higher floor contact pressures than the internal inflation pressure and the loading manuals have formulas for computing allowable loads (or required shoring). Any software/hardware solutions for reducing a vehicle's height for air transport, must be able to withstand the rigors of the transportation environment (shock and temperature extremes).

b. Airdrop. Airdrop is used to support different military operations and provides a flexible option for the military commander. The unmanned ARV variants have an airdrop requirement from C-130 aircraft in an operational configuration. The manned FCS vehicles do not have an airdrop requirement. Before items are airdropped, they must be secured to an airdrop platform. Energy-dissipating material is placed between the item and the airdrop platform to absorb the impact shock when the platform strikes the ground. For vehicles with rubber tires and suspension systems, the maximum airdrop height for the C-130 is 90 inches in order not to exceed 100 inches overall rigged height. The estimated vehicle weight for airdrop from a C-130 is about 34,000 pounds in order not to exceed the current 42,000-pound maximum airdrop weight practices. Actual weight will depend on platform size, parachute types, and other factors. Final airdrop certification will be provided by the Soldier Systems Center at Natick, MA and integrated into the final transportability approval from MTMCTEA prior to Milestone C. Based upon table 1, it is not anticipated that airdrop certification for the ARV will be a problem.

c. Rotary-Wing Air. Rotary-wing aircraft are used mainly for short-range, tactical transport missions. These aircraft have the ability to transport essential equipment directly to a forward area. Table 7 lists the maximum external loads for the UH-60A, UH-60L, and the CH-47D helicopters at a high altitude (4,000 feet) and hot temperature (95 degrees F) (high/hot conditions). Final EAT certification will be provided by the Soldier Systems Center at Natick, MA and integrated into the final transportability approval from MTMCTEA prior to Milestone C. All the manned FCS vehicles exceed the allowable weights for EAT. All the armed robotic vehicles (ARVs) exceed the external lift capability of the UH-60A for the high/hot scenario. The ARV-A and the ARV-RSTA exceed the external lift capability of the UH-60L in the high/hot scenario. All the ARVs are within the external lift capability of the CH-47D. Based upon table 1, it is not anticipated that EAT certification for the unmanned systems will be a problem.

Table 7: Maximum External Loads for EAT

	UH-60A	UH-60L	CH-47D
Maximum Weight (pounds) for EAT at 4,000 feet and 95 degrees F	4,700	6,630	16,644

d. Marine. Water transport is used for both strategic and tactical deployments. Vehicles must have good, accessible lifting and tiedown provisions for marine transport. Therefore, before final transportability approval can be given to the FCS vehicles, they must successfully pass a MIL-STD-209 lifting and tiedown test. Vehicles too heavy for lift by shipboard cranes require dockside cranes at improved ports. Vehicles to be delivered to unimproved ports or underdeveloped areas must be light enough to be lifted by shipboard cranes. Cranes for the Large Medium-Speed Roll-on/Roll-off (LMSR) ships are rated at 36.5 long tons, so crane lifts should not be a problem with the current projected weights of the FCS vehicles. Of the marine craft usually used by the DoD, the two with the smallest carrying capacity are the Navy’s LCM Mk.6 (68,000 pounds) and Landing Craft, Air Cushioned (LCAC) (54,000 pounds). The FCS vehicles must also meet the requirement of negotiating 15-degree ramps without any portion of the vehicle, except the tires or tracks, contacting the surface of the ground, ramp, or deck per reference 1d. The FCS should be capable of unrestricted marine transport.

e. Rail. Rail transport is important in moving vehicles that deploy by land for distances greater than 400 miles. Rail is often more economical than moving the vehicles on trailers on the highway. Moving tactical vehicles by rail also reduces the time the vehicles must operate during deployment and, thus, places them on the front lines in top operational condition. Rail transport on standard-gauge rail lines in North America and Europe is more important than rail transport in other areas of the world due to the fact that rail networks are much more extensive in these areas. There are four rail clearance diagrams of importance. If a vehicle exceeds the following clearance diagrams, it still may be transported by rail; however, special routing and provisions may be required. Prior to the final transportability approval, all variants of the FCS must successfully complete a MIL-STD-810 rail impact test. Since the FCS must meet the dimensional requirements to be C-130 transportable, the FCS should be capable of unrestricted rail transport.

(1) Association of American Railroads (AAR). The AAR diagram for North America (figure 3) is for single loads, without end overhand, on open-top railcars. Vehicles that are mounted on 51-inch-high railcars and fall within the limitations of C-130 transport will be capable of unrestricted movement on almost all rail lines.

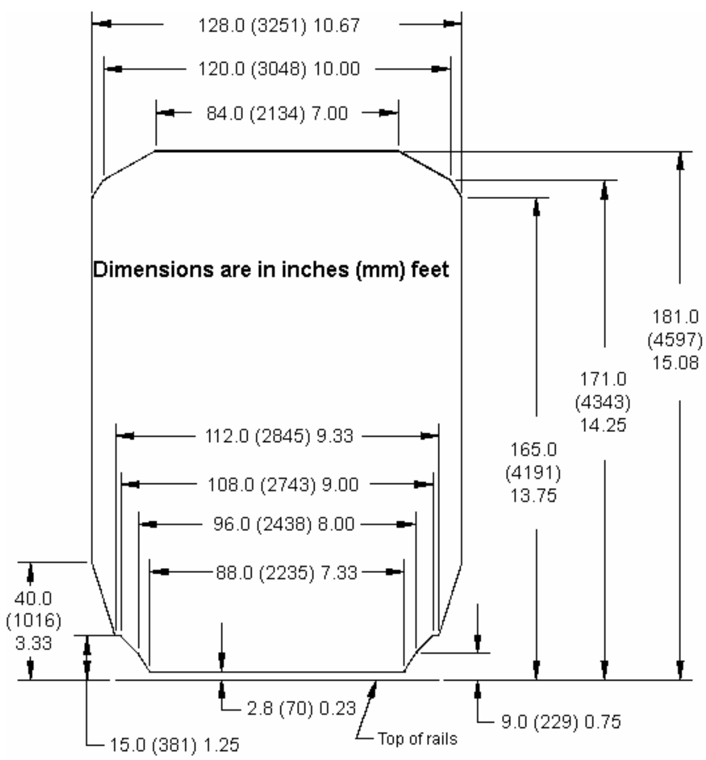

Figure 3: AAR Rail Diagram

(2) DoD Profile for Strategic Rail Corridor Network (STRACNET). The DoD STRACNET clearance profile (figure 4) accommodates 96 percent of current DoD types of equipment. However, it is only valid for selected routes and sometimes only at severely restricted speeds. Other special conditions might also apply.

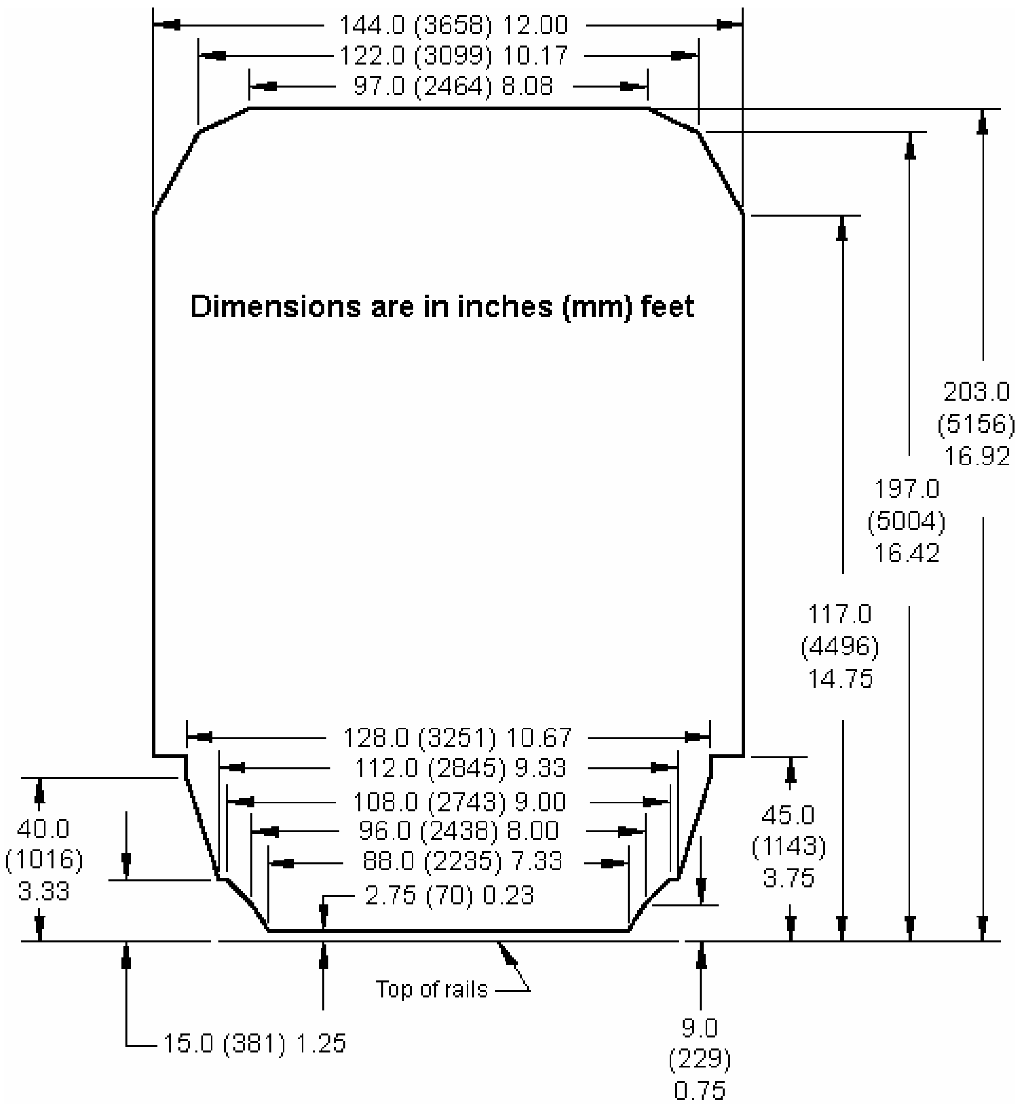

Figure 4: DoD STRACNET Diagram

(3) Gabarit International de Chargement (GIC). The GIC envelope (figure 5) applies to rail lines in European countries. Equipment that is mounted on 51.4-inch-high railcars, and falls within the limitations of the GIC gauge, will be capable of essentially unrestricted movement worldwide on standard-gauge rail lines. The GIC is the most restrictive envelope of the four diagrams shown in this assessment.

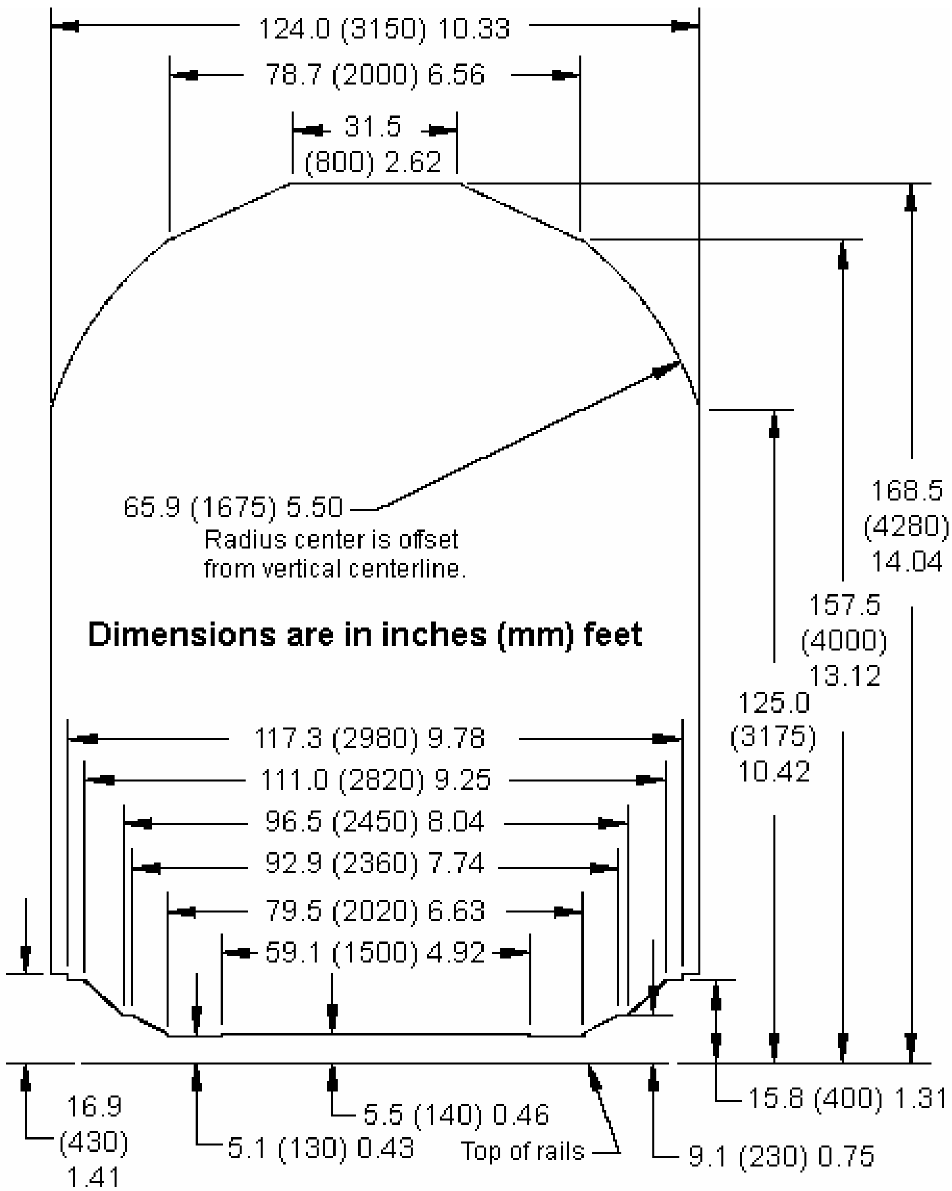

Figure 5: GIC Envelope Diagram

(4) NATO Envelope B. Envelope B (figure 6) applies to rail lines in NATO countries on the European continent. The Envelope B network is not as extensive as the GIC network, but comprises 85 percent of the rail lines.

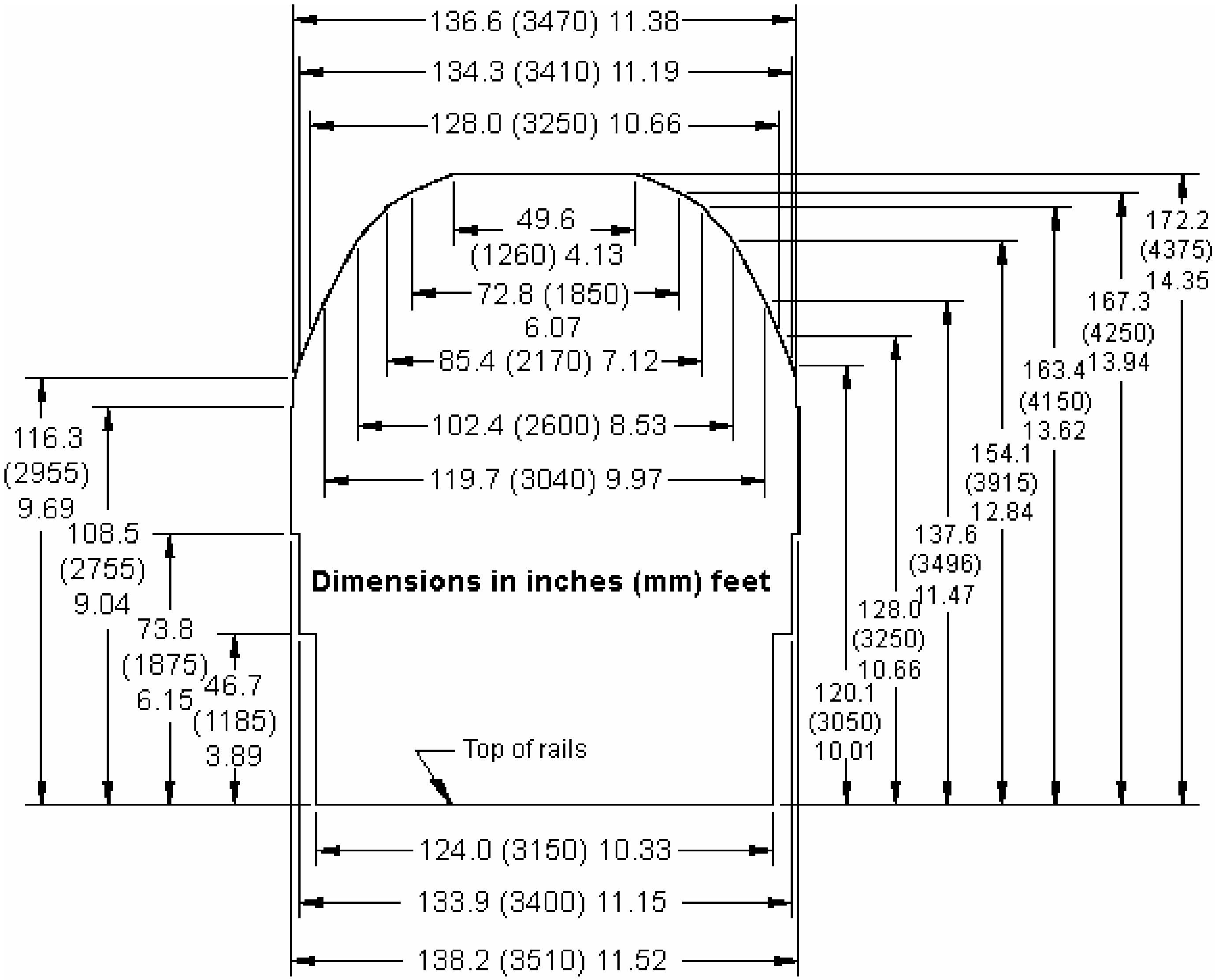

Figure 6: NATO Envelope B

f. Highway. Highway is the most common transport mode for both strategic and tactical deployment. Maximizing the efficiency of the highway network requires that vehicles and vehicular combinations be capable of unrestricted highway movement. This movement is possible if vehicles or vehicular combinations do not exceed legal size and weight limits imposed by the Federal Government, State Governments, and foreign countries. If the dimensional and weight limits shown in table 8 are not exceeded, movement will be generally unrestricted in most States and NATO countries.

Table 8: Dimensional and Weight Limits for Unrestricted Highway Movements

	U.S.	NATO
Length (in inches)	480	393.7
Combination Length (in inches)	660	551.2
Width (in inches)	96	96
Height (in inches)	162	157.5
Single Axle Loads (in pounds)	20,000	22,046

Vehicles that exceed the legal highway limits will require permits for highway movement. The difficulty in obtaining these permits depends on the State's policy and the amount that the legal limit is exceeded. Circuitous routing may be required as a condition of the permit which could result in transport delays. FCS vehicles may require routine permits for highway movements.

7. Deployability Assessment. MTMCTEA's Deployability Analysis branch is currently performing deployment model runs on FCS Time Phased Force Deployment Data (TPFDD) to help determine the lift requirements for the UA. These lift requirements will include rail, air, and sea deployments. These model runs are ongoing as the UA structure continues to evolve and results are not available at this time. Recently, several deployment analyses have been done on various stages of the FCS and Stryker. These analyses include:

a. Stryker Analyses. The deployability of the Stryker Brigade Combat Teams (SBCTs) was addressed in the Defense Planning Guidance (DPG) directed Operational Availability (OA) Study and a corresponding USTRANSCOM analysis in 2002. In both of these analyses, it was determined that the 96 hour force closure timeline could be met if the SBCT total weight was kept below 10,000 short tons (with 25% of the planes carrying "hot cargo" (ammunition) which required special hot cargo loading areas). The findings from these studies are certainly applicable to the deployment of the FCS UA.

b. Center for Army Analysis (CAA) Analysis of Alternatives. CAA is currently performing an analysis of alternatives for the FCS. This analysis will compare a mix of legacy forces, SBCTs, and the FCS UA in a deployment scenario. Since this is an ongoing analysis, results are not available at this time.

c. DPMO MAPEX. On 15-16 April 2003, DPMO at Ft. Eustis, VA, held a MAPEX to run various deployment vignettes of the FCS UA in a Caspian Sea scenario. Using assumptions such as a 16 – 18 ton ECC FCS vehicle, high Maximum [aircraft] on Ground (MOG) rates, aircraft availability, and sustainment available on site, the UA closed in 6 days (144 hours) when using an intermediate staging base (ISB) where a transload from C-5s and C-17s to C-130s took place. When deploying directly to the Area of Operations (AO) from CONUS using only C-5s and C-17s, the UA was able to close in 5 days (120 hours). In the "vertical maneuver" vignette, the UA was moved by 144 C-130s from one location in theater, to another location 151 NM away using 5 airfields with a combined MOG of 10. Flying 535 sorties, it took just over 95 hours to move the UA 151 NM (see KPP #4, paragraph 4 on page 3). The DPMO analysis is ongoing and further model runs under other conditions and assumptions will be made to help determine the best way to meet the 96 hour deployment requirement.

8. As FCS reaches Milestone B, the estimated weights of the FCS manned vehicles continue to increase. While the vehicles are still only computer models, some of the ECC weights have increased from the original estimate of 32,000 pounds (16 tons) for C-130 transport, to over an estimated 49,600 pounds (24.8 tons). Reference 1e states the following:

> *"As the Army prepares to usher in a new family of combat vehicles, it is important to review the weight growth history of past combat vehicles. The purpose of this review is to ensure that lessons learned from these past programs are applied to current and future acquisition programs. The Army has developed, fielded, and upgraded several families of combat vehicles over the past four decades. All have experienced significant weight growth over time. This weight growth contributed to the increase in the Army's deployment footprint over the years and affected the transportability of the individual systems. While the effect of weight growth may be most visible during air transport, it affects all modes of transportation."*

9. The weight growth experienced so far in the proposed FCS manned vehicles is before manufacturing has begun. Empirical evidence shows that combat vehicles (manned and unmanned) can be expected to grow by an additional 23% to 50% during their life cycle. The enhanced capabilities expected with FCS Increment 2 and above, and the equipment that provides those capabilities, may add more weight to the vehicles.

10. Due to the FCS procurement strategy, any changes in transportability characteristics, such as weight growth, between increments may necessitate additional transportability testing. For example, any increase in weight raises a question about the testing of Increment 2 and above

vehicles and different vehicles within an increment. If the Increment 1 vehicles are tested at one gross vehicle weight and Increment 2 (and above) vehicles show an increased weight due to new equipment that has been added, new transportability testing may have to be performed on those Increment 2 (and above) vehicles. The lifting and tiedown provisions that passed a MIL-STD-209 lifting and tiedown test for Increment 1, might not be adequate to secure a heavier vehicle for Increment 2 and above. Therefore, MTMCTEA will have to monitor future Increment improvements to determine if new transportability testing is required, and the Program Manager (PM) should ensure adequate time and funding is available to accomplish any additional testing.

11. Once the FCS contractors have submitted their final transportability reports for their vehicles (both manned and unmanned) and transportability testing (MIL-STD-209 lifting and tiedown provision testing and MIL-STD-810 rail impact testing) is complete, MTMCTEA will review the reports and test results to determine if the vehicles meet their transportability requirements. If they meet the requirements, transportability approval will be granted prior to Milestone C.

12. MTMCTEA will continue to monitor developments with the FCS program and assist the PM and the materiel and combat developers through advice and guidance, and through the working group discussed in paragraph 3.2 of reference 1g, to ensure the safe and efficient transport of the FCS vehicles via the Defense Transportation System. The project engineer for the FCS for MTMCTEA DSN 826-4643, (757) 599-1665, or email: dpemail@tea.army.mil.

Original Signed
Director, MTMCTEA